

# Claims

- [c1] 1. A method of fabricating a deep trench capacitor, comprising:
- providing a substrate, wherein the substrate has a patterned liner layer and a patterned mask layer formed thereon and a deep trench formed therein, an electrode formed at a bottom of the deep trench in the substrate and a capacitor dielectric layer formed on the surface of the deep trench;
  - forming a first conductive layer at the bottom of the deep trench;
  - forming a protective layer over the mask layer and on the surface of the deep trench;
  - forming a collar oxide layer on the surface of the protective layer;
  - removing the protective layer and the collar oxide layer on the surface of the first conductive layer;
  - depositing a material into the deep trench to form a material layer;
  - removing a portion of the material layer inside the deep trench to form a first opening, wherein a top surface of the material layer is at a level higher than the liner layer;
  - removing the collar oxide layer and the protective layer

not covered by the material layer;  
removing a portion of the mask layer and the protective layer on the sidewall of the first opening to form a second opening, wherein the second opening has a width greater than the first opening;  
removing the material layer;  
depositing conductive material into the deep trench to form a second conductive layer;  
removing a portion of the second conductive layer at a top of the deep trench so that the second conductive layer partially fills the deep trench;  
removing the collar oxide layer and the protective layer on the sidewall of the deep trench and not covered by the second conductive layer; and  
depositing conductive material into the deep trench to form a third conductive layer, wherein the third conductive layer completely fills the deep trench.

[c2] 2. The method of claim 1, wherein material constituting the protective layer is selected from a group consisting of silicon oxide and silicon oxynitride.

[c3] 3. The method of claim 2, wherein the step of forming the protective layer comprises performing a plasma-enhanced chemical vapor deposition process.

[c4] 4. The method of claim 1, wherein the step of forming

the collar oxide layer comprises performing a chemical vapor deposition process.

- [c5] 5. The method of claim 4, wherein the step of performing the chemical vapor deposition process comprises using ozone/tetra-ethyl-ortho-silicate as the reactive gases.
- [c6] 6. The method of claim 1, wherein the protective layer has a removal rate smaller than the collar oxide layer.
- [c7] 7. The method of claim 6, wherein the protective layer has a removal rate between about 20 to 35Å/min.
- [c8] 8. The method of claim 6, wherein the collar oxide layer has a removal rate between about 40 to 65Å/min.
- [c9] 9. The method of claim 1, wherein material constituting the material layer is selected from a group consisting of photoresist and anti-reflecting coating.
- [c10] 10. The method of claim 1, wherein the step for removing a portion of the mask layer and the protective layer on the sidewall of the first opening comprises performing a wet etching process.
- [c11] 11. The method of claim 10, wherein the wet etching process is carried out using either hydrofluoric acid/ethylene glycol solution or phosphoric acid solution as

the etchant.

[c12] 12. The method of claim 1, wherein the second opening has a width greater than the first opening by about 5 to 20nm.

[c13] 13. A method of fabricating a deep trench capacitor, comprising:  
providing a substrate, wherein the substrate has a patterned liner layer and a patterned mask layer formed thereon and a deep trench formed therein, an electrode formed at a bottom of the deep trench in the substrate and a capacitor dielectric layer formed on the surface of the deep trench;  
forming a first conductive layer at the bottom of the deep trench;  
forming a collar oxide layer on the surface of the deep trench and the mask layer;  
removing the collar oxide layer on the surface of the first conductive layer;  
depositing a material into the deep trench to form a material layer;  
removing a portion of the material layer inside the deep trench to form a first opening, wherein a top surface of the material layer is at a level higher than the liner layer;  
removing the collar oxide layer not covered by the material layer;

removing a portion of the mask layer on the sidewall of the first opening to form a second opening, wherein the second opening has a width greater than the first opening;

removing the material layer;

depositing conductive material into the deep trench to form a second conductive layer;

removing a portion of the second conductive layer at a top of the deep trench so that the second conductive layer partially fills the deep trench;

removing the collar oxide layer on the sidewall of the deep trench not covered by the second conductive layer;

and

depositing conductive material into the deep trench to form a third conductive layer, wherein the third conductive layer completely fills the deep trench.

[c14] 14. The method of claim 13, wherein material constituting the material layer is selected from a group consisting of photoresist and anti-reflecting coating.

[c15] 15. The method of claim 13, wherein the step for removing a portion of the mask layer on the sidewall of the first opening comprises performing a wet etching process.

[c16] 16. The method of claim 15, wherein the wet etching

process is carried out using either hydrofluoric acid/ethylene glycol solution or phosphoric acid solution as the etchant.

[c17] 17. The method of claim 13, wherein the second opening has a width greater than the first opening by about 5 to 20nm.

[c18] 18. A method of fabricating a deep trench capacitor, comprising:  
providing a substrate, wherein the substrate has a mask layer formed thereon and a deep trench formed therein, an electrode formed at a bottom of the deep trench in the substrate and a capacitor dielectric layer formed on the surface of the deep trench;  
forming a first conductive layer at the bottom of the deep trench;  
forming a protective layer over the mask layer and on the surface of the deep trench;  
forming a collar oxide layer on the surface of the protective layer;  
removing the protective layer and the collar oxide layer on the surface of the first conductive layer;  
depositing conductive material into the deep trench to form a second conductive layer;  
removing a portion of the second conductive layer at a top of the deep trench so that the second conductive

layer partially fills the deep trench;  
removing the collar oxide layer and the protective layer  
on the sidewall of the deep trench not covered by the  
second conductive layer; and  
depositing conductive material into the deep trench to  
form a third conductive layer, wherein the third conduc-  
tive layer completely fills the deep trench.

[c19] 19. The method of claim 18, wherein material constitut-  
ing the protective layer is selected from a group consist-  
ing of silicon oxide and silicon oxynitride.

[c20] 20. The method of claim 19, wherein the step of forming  
the protective layer comprises performing a plasma-  
enhanced chemical vapor deposition process.

[c21] 21. The method of claim 18, wherein the step of forming  
the collar oxide layer comprises performing a chemical  
vapor deposition process.

[c22] 22. The method of claim 21, wherein the step of per-  
forming the chemical vapor deposition process com-  
prises using ozone/tetra-ethyl-ortho-silicate as the re-  
active gases.

[c23] 23. The method of claim 18, wherein the protective layer  
has a removal rate smaller than the collar oxide layer.

- [c24] 24. The method of claim 23, wherein the protective layer has a removal rate between about 20 to 35Å/min.
- [c25] 25. The method of claim 23, wherein the collar oxide layer has a removal rate between about 40 to 65Å/min.